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Review of Motivations, Success Factors, and Barriers to the Adoption of Offsite Manufacturing in Nigeria

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Abstract

Despite several mitigation attempts, Nigeria is still facing a deficit of 17 million houses. Seminal literature argues that this problem is predominantly due to a myriad of issues, including high construction costs, skills shortages, the slow pace of construction, lack of infrastructure and logistics, poor quality of available housing stock etc. Given these issues, offsite manufacturing has been proffered as an innovative method for addressing these challenges. This paper reports on the findings of a substantial literature review investigated the needs, promises and barriers of adopting offsite manufacturing in Nigeria. Seminal literature elaborating on offsite construction and Nigerian construction industry has been thoroughly reviewed and results were analysed using thematic analysis, and Nvivo software was used to code and analyse the research data. Findings highlighted that the housing deficit in Nigeria is on the increase and nothing significant was being done at the moment. The results also posited that although OSM could improve housing delivery efforts in Nigeria, the prevalence of this is still considerably low; and that this was influenced by many factors, such as negative local perception about OSM, client resistance, lack of infrastructure and skills shortage. This study concludes that for OSM to be adopted in Nigeria, there is a need for greater awareness, collaboration, training and encouragement from Government. This study presents additional understanding of OSM in Nigeria based on expert opinion, the results of which were used to develop a framework for the effective adoption of OSM in Nigeria. It is concluded that the adoption of OSM could help support housing delivery efforts in Nigeria, and leverage wider benefits to the industry and associated supply chain.

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1. Introduction

Nigeria is currently facing a significant and progressive housing deficit. Whilst it could be argued that this is similar to many other rapidly developing countries, there are some unique contextual facts that need to be noted. For example, it has a population of 177 million, with an annual growth rate of about 2.5% [1]. It also needs about 17 million new houses in short term [2]. Thus, in order to address these issues, several mitigation efforts have been deployed by the local industry, including: promoting locally manufactured building materials as a means to improve housing delivery [3]; pushing the industry towards better implementation of the Nigeria National Housing Policy [4]; and seeking possibilities for introducing better mortgage systems in Nigeria [3]. Notwithstanding these attempts, a wide margin still exists between housing demand and supply [5]. It has also been argued in seminal literature that these problems are mainly due to the inherent challenges of the exiting conventional housing delivery systems in Nigeria, particularly: time and cost overruns, skills shortage, inadequate quality, and labour intensive activities [4, 6-9]. As such, Dada [10] suggested that a paradigm shift from the conventional construction approach to a more innovative housing production processes was vital for Nigeria.

This kind of radical change in housing delivery methods has also been advocated in several other countries, including the UK [11, 12]; USA [13]; Australia [14] and in South Africa [15]. The essence of all of these major Government reports is that collaborative working and integrated project delivery must be promoted in order to make a 'revolution' in construction projects. To leverage these, seminal literature has proffered the adoption of Modern Methods of Construction (MMC) and Offsite Manufactured Construction (OSM) as viable delivery mechanisms for both developed and developing countries [e.g., 16, 17-22]. In this respect, the primary role of OSM here is to move some of the effort and risk-prone construction site activities into a controlled environment - typically associated with a manufacturing or factory facility [23]. This controlled environment and application of OSM offers several benefits, particularly: a higher speed of construction; improved quality of the finished product; lower costs; and lower labour requirements on-site [21]. These achievements are sustained and significant, which offer a palpable platform for addressing the specific housing problems of Nigeria (discussed above).

Notwithstanding the aforementioned benefits of OSM, the use and deployment of OSM and MMC in the Nigerian housing market is negligible [24]. On this theme, Taylor [19] asserted that failure in many countries could be due to inaccurate public assumptions regarding offsite. Similarly, Arif, Goulding [25] argued that much of this miscommunication among different sectors of the housing industry, could potentially hinder the adoption of OSM and exacerbate the lack of consent between industry and academia in terms of remit, functionality, expectations, motivations, and final goals. In other words, there are multi-aspect drivers that affect the process of industrialising the sector as a whole, not least semantics and technology adoption issues [26]. These are significant challenges. This study therefore posits that, if offsite production and manufacturing are to make a positive contribution to the Nigerian construction industry, there is a need to identify the causal drivers and issues associated with the uptake and adoption of this. This undertaking needs to encompass several areas, not least, market drivers and dynamics, culture, societal issues, and existing economic business models.

Given the importance of these factors, this study investigated these issues within the context of Nigeria; specifically, to identify the pivotal drivers and priorities of OSM for future uptake. The aim of this study is to develop a research roadmap which identifies prioritised areas for OSM adoption in Nigeria. This paper presents the results of in-depth interviews conducted with 26 experts who have been directly involved in Nigerian construction industry for several years, in order to identify the main motivations, success factors, and barriers to the of adoption of OSM in Nigeria.

2. Housing problems in Nigeria

Statistics are not promising on the housing delivery success in Nigeria, where only 10% of Nigerians can currently afford to either purchase or build their desired house, compared to other countries e.g. 72% in USA, 78% in UK, 60% in China, 54% in Korea and 92% in Singapore [27]. Olayiwola and Adedokun [3] noted that the housing situation in Nigeria was far from being satisfactory, taking into account the high rates of urbanisation and population growth. Makinde [4] asserted that there was no perspective of improvement in the near future; if the country decides to continue to rely on its conventional housing delivery systems - which is deficient in terms of quantity and quality of housing units delivered. These problems tend to have a cascading effect that results in other housing problems, such as unstable

businesses, shortage of skills and materials, inadequate infrastructure, lack of innovation and unbalanced distribution of resources.

Globally, skills shortage within the construction industry is a recurrent challenge over the past 30 years [28] and this problem exists in almost all parts of the world to varying degrees. For instance, according to the studies conducted by the CIOB [29] and Schäfer [30], skills shortage have always been a major problem for the housing industries in UK and Germany, respectively. Similarly in Nigeria, Ayedun and Oluwatobi [27] identified this problem as one of the main issues which hampered the effective delivery of housing.

Similar to other countries, the Nigerian construction industry lags behind other industries in terms of new technologies reaching the market [27]. This includes the ‘stiffness’ of the sector in adopting innovative technologies in order to improve the speed and quality of production [10], as well as inadequacy of efforts to comply with the United Nations sustainable development goals for improving cities and human settlements in terms of inclusiveness, safety, resilience and sustainability [31].

In fact, there have been several programmes (initiatives) by different governments in Nigeria that have attempted to leverage housing delivery. However none of these programmes have been successful in making a significant impact [9]. Their failure have been attributed to some fundamental issues such as: inadequate research on the formulation and execution of the programmes, poor implementation of the programmes, and inadequate funding [5]. As a result of all these failures, Nigeria currently requires about 820,000 more housing units annually to bridge the gap between its housing supply and demand [32].

3. Offsite Manufacturing and the Opportunity for Its Adoption in Nigeria

Offsite manufacturing falls under the broad umbrella of Modern Methods of Construction (MMC) [20] and, there are several acronyms associated with OSM. Moreover, Nawi, Lee [33] stated that OSM can be defined as a process and as a system. OSM can also be defined as set of processes that incorporate prefabrication and pre-assembly to produce units and/or modules that are then transported to site and positioned to form a permanent work [34, 35]. From a system point of view, Gibb and Pendlebury [22] defined OSM as a range of applications which involve moving operations that are traditionally completed onsite to a manufacturing environment. This transformation improves the quality, customer satisfaction, efficiency, predictability of delivery timescale and sustainability of a project [20]. It has been widely advocated thorough seminal literature that several benefits are obtainable from the use/adoption of OSM. The following subsections provide a summary of these benefits in accordance to main themes of housing challenges in Nigeria (discussed in the previous section).

3.1. Low-Impact and Sustainable Construction

Ajayi, Koleoso [36] presented statistics about waste generation in Nigerian construction projects, where more than one-ton per day of waste is generated in more than 75 per cent of conventional building sites. They also noted that most waste was generated from demolition works on site and material handling. According to a report by Waste and Resources Action Programme (WRAP, 2007) within the context of the UK, where 40 per cent of all council waste is attributed to construction projects [37], and OSM has been successful by reducing waste generation of typical construction projects by 70% to 90%. It has also been advocated that it is much easier to gather and recycle waste generated from OSM than those for conventional construction projects (WRAP, 2007).

3.2. Speedy Construction and Expedited Delivery

Gibb and Pendlebury [22] advocated the significant value of time for offsite. Similar to other countries, construction projects in Nigeria are often delayed due to issues such as material shortage, skills shortage and poor weather conditions [38]. With OSM, these issues are inherently addressed, since most of the building components are manufactured in factories and transported to site for speedy assembly – with predictable times and specialised workforce [as per discussed with very much detail in: 19, 39-42]. Furthermore, due to the potential of performing parallel activities of site development, foundations, building construction, and plant demands, there is a chance of 30–

50% faster delivery times using OSM (Figure 1), even considering the impact of unpredictable delays in the conventional construction projects [43].

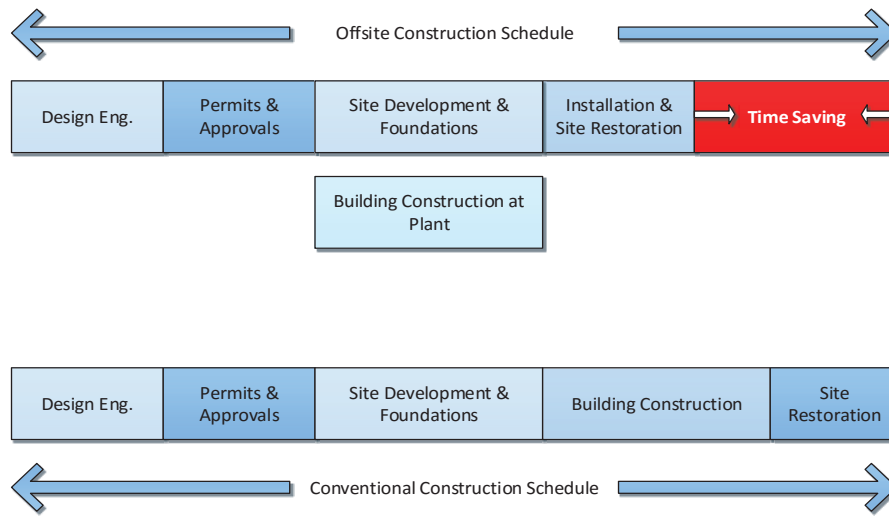


Figure 1: Comparison between OSM Schedule and Conventional Construction Schedule (adapted from [43])

3.3. Reduced Whole Lifecycle Cost

Despite the higher initial cost of OSM projects [44], savings from OSM can be achieved in the areas of cost certainty and reduced risk, reduced running and maintenance costs, reduced preliminaries and site overheads, and reduced construction time [22]. WRAP [45] also identified that savings can be achieved by using OSM as a result of reducing waste of building materials especially bricks. In Nigeria where sandcrete blocks are predominantly used, incorporating OSM has the potential of making a significant impact on the reduction of waste on site, thereby offsetting the initial high cost of OSM.

3.4. Improved Quality of Products

The National Audit Office (NAO [44]) advocated that OSM meets the three quality requirements of durability, whole life cost and performance. It was ascertained that achieving greater quality was a major benefit and a key driver to the adoption of OSM in various contexts, and in different countries such as: India [39]; Australia [46]; and the UK [41]. Gibb and Isack [41] linked this phenomenon to the production quality and output consistency of the controlled factory environment (associated with OSM) as opposed to the uncertain conditions of a conventional construction site.

3.5. Improved Site Logistics

Reduction in wet trades, site disruptions and having more control over projects, has been identified as an important benefit of OSM [41]. Gibb and Isack [41] used the metaphor of working in a prison, explaining how in conventional construction projects contractors have to be escorted to and from their site and all employees have to be properly scrutinised. Whereas, OSM is capable of minimising the level of unnecessary travel (even relocations) by workers to construction sites as well as on-site patrolling activities, since every party produces the components in their own premises. They therefore only appear on the site for very short assembly times.

4. Potential Barriers to Adoption of Offsite Manufacturing in Nigeria

Despite the aforementioned benefits, seminal literature has also highlighted a myriad of barriers that can hinder the successful uptake of OSM in different countries [e.g., 18, 39, 47, 48]. Acknowledging these issues, this research purposefully investigated these barriers from primary data evidence regarding their likelihood to shape/inform the research context of Nigeria.

One of the initial barriers is that of perceived cost. Initial cost has been acknowledged as a main barrier to the uptake of OSM in many countries, for example: India [39]; New Zealand [48]; and Nigeria [49]. Manufacturing capacity was another barrier to the uptake of OSM. These issues are not as apparent in countries where OSM has already been established, (e.g. UK, US, Japan and Nordic countries) as these tend to have a robust supply chain including manufacturing factories to support the OSM market. However, in countries like Nigeria, there are only few factories involved in the manufacturing of OSM components. This can certainly hinder uptake of OSM. Another barrier is the perceived negative public and stakeholders' perceptions towards OSM. Arif, Bendi [39] argued that one reason for this is that prefabricated housing was used during periods of high demand (e.g. First and Second World Wars with various types of housing system based on pre-cast/in-situ concrete, timber, steel/iron variants); and the resultant product was relatively "low quality", with a short lifespan. Although OSM has advanced significantly from this era, Opara [49] confirmed that similar negative perception still is a real barrier for the adoption of OSM in Nigeria.

Other barriers associated with the adoption of OSM is the lack of suitable building codes and standards [18]. This is also a problem in Nigeria, where no official codes or standards exist to guide the use of OSM. This is compounded when factoring in the shortage of skilled workers and labour-specific requirements for OSM deployment [18]. This problem is expounded in countries like Nigeria where the OSM industry is relatively small and reliant on expatriate skills [49]. A summary of the key benefits and barriers to OSM adoption can be seen in Table 1.

Table 1: Summary of the major benefits and barriers to OSM adoption identified by various studies in the contexts of different countries

| Conducted Studies | Context | OSM Benefits | | | | | | | | | | Barriers to OSM Adoption | | | | | | | | | |
|------------------------------|-----------|--------------|-------------------------|---|------------------|----------------|-----------------|--------------------|-----------------|------------------------|-----------------|--------------------------|-------------------|----------------------------|--------------------------------------|---|--------------------|----------------|-------------------|------------------------------|----------------------------|
| | | Speed | Reduced Whole Life Cost | | Improved Quality | Sustainability | Health & safety | Consistent Product | Waste Reduction | Logistics & Operations | Reduced Defects | Increased Value | High Initial Cost | Limited Design Flexibility | Shortage of Local Skills & Knowledge | Lack of Government Policies & Regulations | Nature of Industry | Negative Image | Client Resistance | Infrastructure and Equipment | Logistics and Supply Chain |
| Arif and Egbu (2010b) | China | * | | * | * | * | | * | | | | * | | * | | | | | * | * | |
| Arif <i>et al.</i> (2012a) | India | * | * | * | * | | | * | | | * | * | * | * | * | * | * | * | * | * | * |
| Blismas <i>et al.</i> (2005) | UK | * | * | * | * | * | | | | | | * | * | * | | | | | * | | * |
| Blismas <i>et al.</i> (2006) | UK | * | | * | | * | | | * | | | | | | | | | | | | |
| Elnaas <i>et al.</i> (2014) | UK | | | * | * | * | | | | | | * | | * | * | | * | | * | * | * |
| Fussell <i>et al.</i> (2007) | Australia | * | | * | * | * | | * | * | | | * | * | * | * | * | * | * | | | * |
| Goodier and Gibb (2005) | UK | * | | * | * | | * | | | * | * | * | | * | * | | * | * | | | |

| | | | | | | | | | | | | |
|---------------------------------|-------------|---|---|---|---|---|---|---|---|---|---|---|
| Gorgolewski (2003) | UK | * | * | * | * | * | * | * | * | * | * | * |
| Jaillon and Poon (2010) | Hong Kong | * | | * | | * | | | * | * | * | * |
| Larsson and Simonsson (2012) | Sweden | * | | | * | * | | | | | | * |
| McGraw-Hill Construction (2011) | USA | * | | * | | * | | | * | | * | * |
| Nawi et al. (2011) | Malaysia | * | | * | * | * | | * | * | * | | * |
| PrefabNZ Incorporated (2013) | New Zealand | * | | * | | * | | | * | * | | * |
| Zhai et al. (2014) | China | | | | | | | | * | * | * | * |

5. Future Development Roadmap

Figure 2 presents a development roadmap based on the findings from this research. This roadmap summarises the motivations, success factors, and barriers associated with the adoption of OSM in Nigeria. This was initially developed from literature, and refined with the engagement of principal stakeholders from Nigeria. This roadmap is the first of its kind to specifically focus on: Barriers, Actions, Stakeholders and Goals (within the context of Nigeria). The barriers to OSM adoption in Nigeria were derived from expert opinions. This opinion included major stakeholders who had significant roles to play in OSM, and by default, any future actualisation of a roadmap of this nature. From this roadmap each barrier (green), mitigation actions (yellow), stakeholder involvement (purple), and goals (blue) are identified to deliver this roadmap.

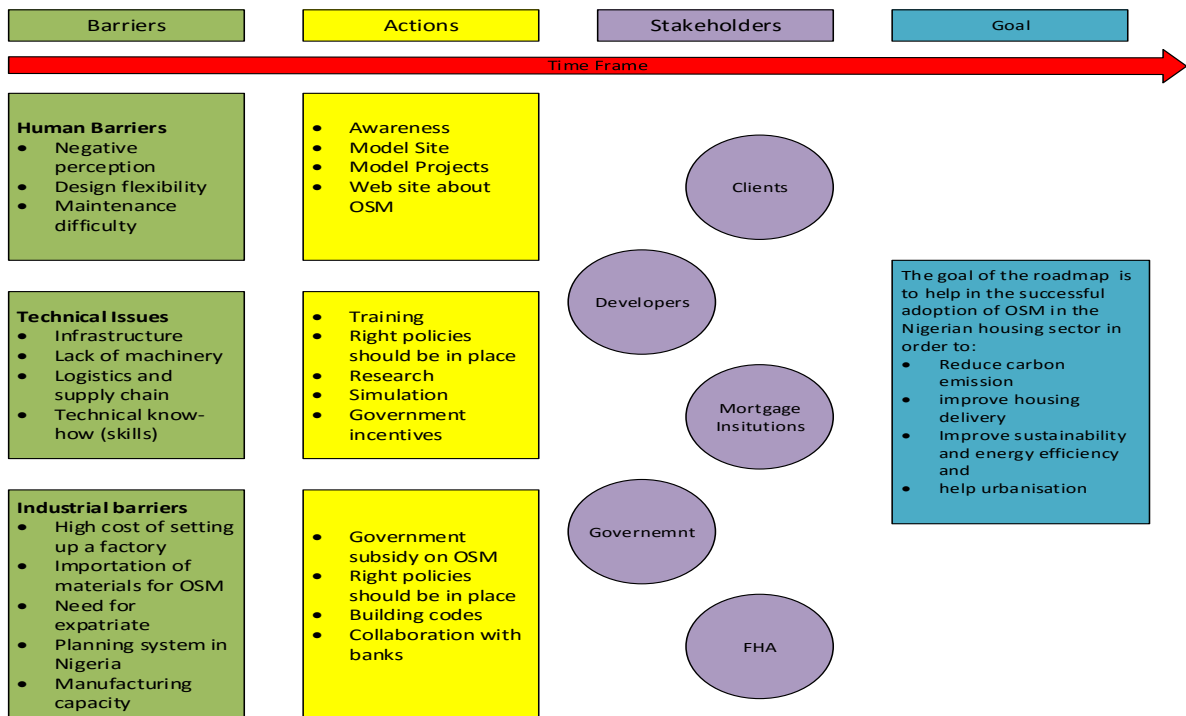


Figure 2: Outline Roadmap for the Adoption of Offsite Manufacturing in the Nigerian Housing Sector

6. Conclusion

Research findings indicate that whilst there is still a large housing deficit in Nigeria, there are currently no significant measures implemented to address this challenge. However, OSM has been proffered as a potential solution, particularly though its ability to meet volumetric delivery patterns with reduced costs and improved quality thresholds. That being said, contextual conditions need to be assessed before this can be considered a viable solution. In doing so, several barriers to OSM adoption were presented and discussed. Low-impact construction methods (such as OSM) are considered viable methods for both improving sustainability per se, but also feasible solutions for improving this housing deficit.

This study presented a series of underpinning steps needed to address the housing challenge, which included the concepts and possibility of OSM adoption in Nigeria. Whilst the context-specific OSM challenges presented in the outline roadmap highlighted barriers, actions, stakeholders involved and goals required, this research can only be considered the starting point for future studies. There is an exigent need to investigate these issues further, as it is important to proffer bespoke solutions to this environment e.g. infrastructure and local suitable materials for OSM. For this to be achieved, the experience garnered from other contexts need to be evaluated regarding their suitability and potential embeddedness.

The outline roadmap presented in this paper embeds the views and opinions of a number of high level stakeholders and respondents. This was needed to not only shape the boundaries (scope), but also focus on specific priorities and deliverables. For example, the barriers to OSM adoption in Nigeria are highly contextualised, multi-layered and complex. This roadmap is the first step in capturing these variables. It will however need to be refined and populated in more detail with specific, measurable, achievable, realistic and time-framed (SMART) objectives – so that clear priorities and directions can be established. Given this, from a generalisability and repeatability perspective, interpretation is confined, limited to the data set and context highlighted in this study.

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